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## (54) SOFT AUSTENITIC STAINLESS STEEL

### (57)Abstract:

PROBLEM TO BE SOLVED: To produce an Ni low reduction type inexpensive soft austenitic stain less steel applicable to services in which common steels or the surface treated steel sheets thereof or brass, etc., are used and corrosion resistance higher than that of surface treated steel sheets and hot workability equal to that of SUS304 are secured.

SOLUTION: This stainless steel is the one having a compsn. contg., by mass,  $\leq 0.04\%$  C,  $\leq 1.0\%$  Si,  $\leq 5.0\%$  Mn, 15 to 20% Cr, 5 to  $< 9\%$  Ni,  $\leq 0.035\%$  N and 1.0 to 5.0% Cu, in which the content of S is limited to  $\leq 0.0060\%$ , and the balance Fe with inevitable impurities, also, the relations in inequality I:  $(d) \text{ value} = 1.9\text{Ni} + 32\text{C} + 27\text{N} + 0.15(\text{Mn} + \text{Cu}) - 1.5\text{Cr} + 8.5 \leq 0$  and inequality II:  $(a) \text{ vale} = \text{Ni} + 0.5\text{Cr} + 0.7(\text{Mn} + \text{Cu}) - 18 > 0$  are satisfied, and its hardness is regulated to Hv $\leq 130$  after annealing.

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CLAIMS

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[Claim(s)]

[Claim 1] By mass %, less than [ nickel:5-9% ], N:0.035% or less, and Cu:1.0-5.0% are included C:0.04% or less less than Si:1.0% ], less than [ Mn:5.0% ], and Cr:15-20%. The elasticity austenitic stainless steel which S content is restricted to 0.0060% or less, and the remainder consists of Fe and an unescapable impurity, and satisfies the relation between following the (1) formula and (2) formulas, and serves as 130 or less-Hv hardness in the state after annealing.

d value =  $1.9\text{nickel} + 32\text{C} + 27\text{N} + 0.15(\text{Mn} + \text{Cu}) - 1.5\text{Cr} + 8.5 \leq 0$  ... (1)

a value =  $\text{nickel} + 0.5\text{Cr} + 0.7(\text{Mn} + \text{Cu}) - 18 > 0$  ... (2)

[Claim 2] The elasticity austenitic stainless steel according to claim 1 which restricted S content to 0.0030% or less.

[Claim 3] The elasticity austenitic stainless steel according to claim 1 which contains B:0.03% or less further.

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DETAILED DESCRIPTION

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## [Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] Processability is a good austenitic stainless steel in elasticity, and this invention relates to the elasticity austenitic stainless steel which can be used suitable also for the building-materials use as which surface crack generating at the time of hot rolling is suppressed, and design nature is required especially.

## [Description of the Prior Art]

[0002] Conventionally, for materials for sheet metal fabrication, such as a structural inside-and-outside board, a plain steel or its surface treated steel sheet is used abundantly from a viewpoint of processability and economical efficiency at road transport department material or the vessel row. There are also many uses which point to stainless steel-ization of these materials from the demand of improvement in design nature or corrosion resistance in the field for which these plain steels or its surface treated steel sheet is used recently. However, generally stainless steel is not elasticity like a plain steel. For this reason, in the facility currently used for processing of a plain steel, un-arranging arose in processings, such as a shortage of torque, and there was a problem that application was difficult.

[0003] As an example which attained elasticity-ization of an austenitic stainless steel, the austenitic stainless steel which realized 130 or less Hv and the with a 55 kgf/mm tensile strength [ or less 2 ] elasticity property is indicated at JP,4-72038,A by making nickel content increase to 9.0% or more, while reducing an impurity element. Moreover, in JP,6-279955,A, Cr is reduced to less than 15%, a cost fall is aimed at, and the austenitic stainless steel which attained elasticity-ization is indicated by restricting severely the content lower limit of the parts nickel, Mn, and Cu.

[0004]

[Problem(s) to be Solved by the Invention] However, since the steel of JP,4-72038,A has high nickel content, it is quite disadvantageous in respect of cost compared with a plain steel or its surface treated steel sheet. Although the steel of JP,6-279955,A has \*\*\*\*\*-proof exceeding the aluminum killed steel of a plain steel, Cr content has come [ moreover, ] to show about the same corrosion resistance as a surface treated steel sheet, especially the persistence time, i.e., endurance, to \*\*\*\*, too to a low sake.

[0005] Furthermore, in the conventional elasticity austenitic stainless steel, the problem and the bird clapper had many troubles accompanying a hot-working nature fall where the surface crack which is in the inclination which adds many austenite generation elements just because it thinks the "elasticity-ization" as important, carries out a cause also of that, and an ear crack arises or is called "sliver crack" at the time of hot rolling occurred. Such surface discontinuity is disliked especially in the use which means design nature.

[0006] Then, this invention is set to the austenitic stainless steel which attained elasticity-ization to the grade applicable in the field for which nonferrous metal alloys, such as a plain steel, its surface treated steel sheet, or brass, are used. Reduce the amount of nickel, hold down cost and the corrosion resistance exceeding a surface treated steel sheet moreover is given. in addition -- and it aims at offering the austenitic stainless steel which the yield can be good also for the use which raises hot-working nature just like SUS304, prevents generating of surface discontinuity, and attaches importance to design nature, and can be applied

[0007]

[Means for Solving the Problem] The above-mentioned purpose is mass % and contains less than [ nickel:5-9% ], N:0.035% or less, and Cu:1.0-5.0% C:0.04% or less less than [ Si:1.0% ], less than [ Mn:5.0% ], and Cr:15-20%. S content is restricted to 0.0060% or less, and the remainder consists of Fe and an unescapable impurity, and the relation between following the (1) formula and (2) formulas is satisfied, and the elasticity austenitic stainless steel which serves as 130 or less-Hv hardness in the state after annealing can attain.

$$d \text{ value} = 1.9\text{nickel} + 32C + 27N + 0.15(\text{Mn} + \text{Cu}) - 1.5\text{Cr} + 8.5 \leq 0 \dots (1)$$

$$a \text{ value} = \text{nickel} + 0.5\text{Cr} + 0.7(\text{Mn} + \text{Cu}) - 18 > 0 \dots (2)$$

Moreover, especially this invention contained B in 0.03% or less of range in the thing which restricted S content to 0.0030% or less among the above-mentioned stainless steel, and the pan, and makes thing offer.

[0008]

[Embodiments of the Invention] Hereafter, the matter which specifies this invention is explained based on a test result. The sample was produced as follows. Steel No. 1-24 to which the various alloy-element contents shown in Table 1 were changed were ingoted, and each steel was given at 1250 degrees C, it hot-rolled after forging and at the extraction temperature of 1230 degrees

C, and the hot rolled sheet steel of 3.2mm of board thickness was obtained. Hot-rolling board annealing and pickling for 1150 degrees C, and soaking 1 minute were performed to this hot rolled sheet steel, it cold-rolled to 1.4mm \*\* after that, and intermediate annealing and pickling for 1050-degree-C soaking 1 minute were performed, it finished and cold-rolled to 0.7 moremm \*\*, and finishing annealing and pickling for 1050-degree-C soaking 1 minute were performed. Thus, the cold rolled sheet steel (annealed material) was obtained.

[0009] (Corrosion resistance) The 150x150mm test piece was extracted from the above-mentioned cold rolled sheet steel, and the salt spray test of JISZ2371 was performed. The salt spray test sprayed the NaCl solution at 35 degrees C 5%, judged rust generating by viewing and evaluated it in time required by then. In addition, 8 micrometers in galvanization thickness, 0.5g of chromate films/, and the electrogalvanizing common steel plate of m2 were used as comparison material.

[0010] A test result is shown in Table 2. Moreover, as the relation between Cr content and rust generating time is known, it shows the result to drawing 1. As Table 2 and drawing 1 show, time to result in rust generating of the electrogalvanizing common steel plate used for comparison is 260hr(s). And when Cr content is 15% or more, rather than this, the durable time to rust generating becomes long, and comes to show corrosion resistance higher than an electrogalvanizing common steel plate. Therefore, this invention prescribes Cr content to 15% or more.

[0011] (Hot-working nature) About steel No.1-24 shown in Table 1, from the columnar-crystal section of casting slab, the ingot with the thickness of 30mm, a width of face [ of 140mm ], and a length of 150mm was started, the hot rolling by the REBASU type rolling mill was carried out, and hot-working nature was evaluated. Rolling conditions are shown in Table 3. The number of paths which the ear piece generated was checked visually, and it considered as the evaluation index of hot-working nature. Furthermore, the sliver crack which is the surface discontinuity generated on the steel plate front face after hot-rolling was counted, and the number of slivers per unit area was made into the evaluation index.

[0012] The result is shown in Table 2 and drawing 2. An interesting result is known from drawing 2. That is, while d value which (1) formula defined increases, the number of paths which results in generating of an ear piece falls, and generating of a sliver increases. And a clear correlation is between d value and hot-working nature, and especially sliver crack occurrences show d value and a clear straight-line relation. That is, it can be said that d value is the index by which the grade of generating of the surface discontinuity resulting from hot rolling can be evaluated with a very sufficient precision.

[0013] If it is going to apply elasticity stainless steel to the use which employed beautiful [ of the surface skin ] efficiently, there is no generating of an ear piece at the time of hot-rolling, and if generating of a sliver crack is not suppressed or less [ at most 10 //m ] to two, moreover, it will not be stood to dominance in respect of quality compared with the conventional material, such as a surface treated steel sheet and a nonferrous metal alloy. This invention persons found out that it was stabilized and a steel plate with which an ear piece is not generated and generating of a sliver becomes two or less [ 10 //m ] could be manufactured in the austenitic stainless steel by which the quality governing was carried out that this d value is zero or less so that drawing 2 might show. This point is one of the fundamental features of this invention. For steel No.8 to which d value furthermore added B or less by zero, and steel No.7 which reduced S content, the quality which whose sliver occurrences by hot rolling are zero piece/m2, and was further excellent is \*\*\*\*\*. On the other hand, although d value was zero or less, the ear piece generated steel No.10 to which S content exceeds 0.0060%, and sliver occurrences are also over ten pieces/m2.

[0014] S in a hot rolling temperature region carries out the segregation of the degradation of the hot-working nature of an austenitic stainless steel to the interface of an austenite grain boundary or an austenite phase, and a delta-ferrite phase, and it is thought that it originates in reducing the bonding strength of these grain boundaries or an interface. On the other hand, a delta ferrite is considered that the degree of dissolution of S is high compared with an austenite phase. (1) the Ming kana from a formula -- d value falls with the fall of an austenite generation element content like That is, in low component composition, the amount [ in / a hot rolling temperature region / in d value ] of delta-ferrite generation increases. And it is imagined as what the delta-ferrite phase which d value generated in the moderate amount in zero or less component composition in the hot rolling temperature region dissolves S, the deformability at the time of hot-rolling improves since the interface bonding strength of an austenite phase and a delta-ferrite phase therefore increases, consequently loses ear piece generating, and can reduce generating of a sliver to ten pieces/m2.

[0015] It is thought that S content which exists in steel originally depends [ in addition to dissolution of S by the delta ferrite ] on the result [ that hot-working nature improved very much in the aforementioned steel No.7 whose S content d value is zero or less, and is 0.0020% or less ] by which the fall of the interface bonding strength of an austenite phase and a delta-ferrite phase was suppressed further for a low reason. Conversely, by the aforementioned steel No.10 by which S content exceeds 0.0060% although d value is zero or less, S which carries out a segregation to an interface also by S dissolution by the delta ferrite cannot fully be absorbed, consequently it is thought that good hot-working nature was not obtained.

[0016] Furthermore, it is thought that B is an element which demonstrates the operation to which the segregation also of the left hand lay is preferentially carried out, and the bonding strength of an interface is increased according to the segregation in addition to the interface of an austenite phase and a delta-ferrite phase. Therefore, it is thought that steel No.8 which added B have an effect on much more hot-working disposition.

[0017] (Elasticity property) The sample was extracted from the aforementioned cold rolled sheet steel, and the Vickers determination of hardness specified to JIS2244 was carried out. The result is shown in Table 2.

[0018] The relation between a value and hardness is shown in drawing 3 about steel No.7-9, and 11-22. If the inclination for hardness to fall with the increase in a value is shown and a value exceeds 0, it turns out that it is elasticity-ized by 130 or less Hv. That is, when nickel content adjusted the component in the austenitic stainless steel with which Cr content is 15% or more

including 1 - 5% of Cu at less than 9%, and d value filled zero or less so that a value might exceed 0, hot-working nature was good and hardness found out that a 130 or less-Hv elasticity austenitic stainless steel was obtained. This point is the 2nd feature of this invention. When it considers as the chemical composition to which a value exceeds 0 by such component system, in order that the austenite phase of a cold rolled sheet steel may be stable, work hardening is suppressed, and it is thought that elasticity-ization is attained.

[0019] By the way, in drawing 3, if C and N content are high even if a value exceeds 0 like steel No.18 or steel No.21, it will be expected that hardness rises by solid solution strengthening. Then, about that to which d value fills zero or less, and a value exceeds 0, C and N content investigated the influence which it has on hardness, and obtained the relation between drawing 4 and drawing 5.

[0020] The Vickers hardness number of steel No.8, and 19-21 to which N content was changed from 0.012% to 0.043%, and the relation of N content are shown by using 7nickel-16.5Cr as the base at drawing 4. Moreover, the Vickers hardness number of steel No.7, and 16-18 to which C content was changed from 0.010% to 0.049%, and the relation of C content are shown by using 7nickel-16Cr as the base at drawing 5. An increase of N content or C content increases hardness. In order to elasticity-ize to 130 or less Hv, it turns out that it is necessary to make the amount of N 0.035% or less, and to make the amount of C 0.040% or less.

[0021] Next, the reason for limitation of each component element is explained.

C: If C is contained so much, proof stress will rise 0.2% by solid solution strengthening, and hardness will increase it as mentioned above. For this reason, a content is restricted to 0.04% or less.

[0022] N: If N as well as C is contained so much, proof stress will rise 0.2% by solid solution strengthening, and hardness will increase as mentioned above. For this reason, a content is restricted to 0.035% or less.

[0023] Although Si:Si is an effective element as a deoxidizer at the time of an ingot, in order to maintain elasticity nature, it becomes difficult for the content to fill 130 or less-Hv hardness, if the method of a low is desirable and exceeds 1.0%. For this reason, it is necessary to regulate to 1.0% or less of content (for it not to contain 0%). Furthermore, it is very effective to reduce Si content when making the "springback" in bending small. When the amount of springbacks after bending was measured about the steel plate of 1mm of board thickness as an example and the R/t value when setting a bending section radius to R and setting board thickness to t was 6, in what made Si content less than 0.5% among this invention steel to the amount of springbacks having all been 3 degrees in commercial SUS304 and a commercial galvanized steel sheet, it became 2 degrees. Moreover, when a R/t value was 10, in what made Si content less than 0.5% among this invention steel to each having been 6 degrees in commercial SUS304 and a commercial galvanized steel sheet, it became 4 degrees. Since the amount of springbacks will become large if Si content becomes 0.5% or more when applying to building-materials uses, such as a roof, a shell plate, etc. fabricated to the corrugated plate of a small bending angle with a press, configuration freeze nature deteriorates, and there is a possibility of producing the problem that a desired configuration is not acquired. Therefore, it is desirable to make Si content into less than 0.5% in a building-materials use.

[0024] Although Mn:Mn is desirable to elasticity-izing since proof stress declines 0.2% with the increase in a content, there is a possibility of the refractories injury at the time of steel manufacture being caused if contained so much, and inclusion increasing, and spoiling the design nature of a product. Therefore, it specifies to 5.0% or less of content (it does not contain 0%) with which the effect of elasticity-izing is saturated.

[0025] S: Since hot-working nature deteriorates with the increase in a content, restrict S to 0.0060% or less of content. Moreover, when aiming at much more hot-working disposition top, restricting to 0.0030% or less is desirable.

[0026] nickel:nickel is an element indispensable to an austenitic stainless steel, and it needs at least 5%. A property [ elasticity / increase / in the content ] / is shown. However, nickel is an expensive element, and since elasticity nature can be attained by less than 9.0% of content, the upper limit is made into less than 9.0% in this invention which means cheap-ization.

[0027] Cr:Cr needs to consider as 15% or more from a corrosion resistance point. However, since hardness will increase from the point of elasticity-izing if contained so much, the upper limit is made into 20% or less.

[0028] Cu:Cu needs 1.0% or more for being the useful element which elasticity-izing and a moldability contribute to improvement, and acquiring the effect. In this invention which furthermore means nickel reduction, by considering as Cu content exceeding 2.0%, the flexibility of nickel content is expanded, it becomes easy to reduce nickel to about 5% which is the lower limit, and it can contribute to cost reduction further. For this reason, although the minimum of Cu content considers as 1.0%, it is desirable to make it contain exceeding 2.0%. On the other hand, since superfluous content has a bad influence on hot-working nature, the upper limit of a content is made into 5.0%.

[0029] Mo: Although Mo is not an indispensable alloying element in this invention, as for Mo, it is effective to add Mo, since it is an element useful on an anti-corrosion disposition, especially when applying to the use of building materials, such as a roof and a shell plate, etc. However, since elevation of hardness will be caused if it exceeds 3.0%, when adding Mo, it is desirable to consider as 3.0% or less of range.

[0030] B: B is an element useful to improvement in hot-working nature. It is very effective, when especially S content exceeds 0.0030% and raising hot-working nature by B addition extends the flexibility of the content of other alloy elements. However, if B is made to contain exceeding 0.03%, hot-working nature will come to deteriorate on the contrary. Therefore, in adding B, it considers as 0.03% or less of content range.

[0031]

[Example] Steel No.25-33 shown in Table 4 were ingoted, and each steel was given at 1250 degrees C, it hot-rolled after forging and at the extraction temperature of 1230 degrees C, and the hot rolled sheet steel of 3.2mm of board thickness was obtained.

Hot-rolling board annealing and pickling for 1150 degrees C, and soaking 1 minute were performed to this hot rolled sheet steel, cold-rolling was carried out to 1.4mm \*\* after that, intermediate annealing and pickling for 1050-degree-C soaking 1 minute were performed, it cold-rolled again to 0.7mm \*\* after that, and finishing annealing and pickling for 1050-degree-C soaking 1 minute were performed.

[0032] The sample was extracted from the obtained finishing cold-rolled board, and Vickers hardness number was measured. Moreover, from the columnar-crystal section of casting slab, the ingot with the thickness of 30mm, a width of face [ of 140mm ], and a length of 150mm was started, and it hot-rolled on the conditions shown in Table 3 with the REBASU type rolling mill. The number of paths which the surface discontinuity of an ear piece, a sliver, etc. generated was checked visually, and it considered as the evaluation index of hot-working nature. Moreover, the corrosion resistance test was also performed. The test piece size was set to 150mmx150mm, and the salt spray test of JISZ2371 performed corrosion-resistant evaluation. The salt spray test sprayed the NaCl solution at 35 degrees C 5%, and evaluated it in time required by \*\*\*\*.

[0033] These results are collectively shown in Table 5. d value is zero or less and hardness is 130 or less Hv the top where this invention steel No.25-29 to which a value exceeds 0 have good hot-working nature. The \*\*\*\* time of this invention steel containing 15 more% or more of Cr is over 260hr(s) which are the \*\*\*\* time of an electrolytic-zinc plating common steel plate, and shows sufficient corrosion resistance.

[0034] On the other hand, if comparison steel No.30 are compared with this invention steel No.25, although all contain about 7% of nickel, and about 16.5% of Cr To hardness being Hv118 and elasticity, since the content of Mn with this invention steel No.25 [ effective in elasticity-izing ] and Cu is high and a value is over 0, since a value has become [ Mn and Cu content ] low less than zero, as for comparison steel No.30, hardness indicates a high value to be Hv135. Moreover, by comparison steel No.33, if this invention steel No.25 are compared with comparison steel No.33, although Mn and Cu also contain to the same extent in addition to nickel and Cr, since C contains and N all contains both highly with 0.041% 0.050%, hardness indicates a high value to be Hv148.

[0035] Although hardness is 130 or less Hv since, as for comparison steel No.31, a value is over 0, since d value is over 0, hot-working nature is still poorer.

[0036] Moreover, since a value exceeds 0 and d value has become zero or less, although hardness is Hv110 and elasticity and comparison steel No.32 have good hot-working nature, for the 14.3% and low reason, from rust time serves as [ Cr content ] 251hr(s). Therefore, corrosion resistance is inferior to an electrogalvanizing common steel plate.

[0037]

[Table 1]

鋼No.	成分 (wt%)									d値	σ値
	C	Si	Mn	S	Ni	Cr	Cu	N	B		
1	0.019	0.28	1.70	0.0058	8.5	10.8	4.4	0.020	—	10.5	0.2
2	0.021	0.30	1.52	0.0040	6.8	12.5	2.5	0.019	—	4.5	-2.1
3	0.015	0.32	0.78	0.0046	11.2	14.4	0.1	0.006	—	9.0	1.0
4	0.029	0.29	1.17	0.0050	7.0	14.3	2.5	0.020	—	2.4	-1.3
5	0.010	0.13	0.10	0.0048	12.1	16.9	4.5	0.010	—	7.4	5.8
6	0.020	0.1	1.49	0.0040	9.5	15.5	4.5	0.009	—	5.1	3.4
7	0.010	0.31	2.50	0.0012	7.1	16.0	3.4	0.010	—	-0.5	1.2
8	0.012	0.33	2.00	0.0043	7.3	16.5	3.1	0.010	0.005	-1.0	1.1
9	0.018	0.32	2.50	0.0032	6.8	16.8	3.5	0.013	—	-2.0	1.4
10	0.014	0.33	2.50	0.0070	6.2	15.9	3.8	0.011	—	-1.9	0.6
11	0.011	0.29	2.30	0.0044	8.8	16.7	3.1	0.016	—	1.8	2.9
12	0.015	0.32	2.40	0.0048	8.2	15.8	3.9	0.017	—	2.3	2.5
13	0.021	0.28	2.02	0.0032	8.4	15.2	2.9	0.009	—	3.3	1.4
14	0.010	0.33	2.80	0.0051	5.5	15.2	4.1	0.012	—	-2.2	-0.1
15	0.062	0.51	0.20	0.0049	8.1	18.2	0.2	0.030	—	-0.8	-0.5
16	0.022	0.31	2.43	0.0058	6.9	16.2	3.3	0.009	—	-0.9	1.0
17	0.035	0.31	2.60	0.0040	6.8	15.9	3.6	0.012	—	-0.1	1.1
18	0.049	0.31	2.48	0.0049	6.9	16.3	3.4	0.010	—	-0.1	1.2
19	0.010	0.33	2.10	0.0051	7.3	16.5	3.1	0.020	—	-0.7	1.2
20	0.009	0.3	1.98	0.0044	7.2	16.4	3	0.028	—	-0.6	0.9
21	0.013	0.29	2.05	0.0038	7.4	16.6	2.9	0.043	—	0.0	1.2
22	0.010	0.29	4.80	0.0052	5.1	13.0	4.5	0.008	—	0.6	0.1
23	0.008	0.31	4.10	0.0046	5.8	13.5	4.3	0.012	—	1.1	0.4
24	0.012	0.33	4.30	0.0040	6.2	14.6	3.1	0.010	—	0.1	0.7

[0038]

[Table 2]

鋼No.	塩水噴霧試験 赤錆発生時間 (Hr)	耳切れ発生 パス (段目)	スリーパー 発生数 (ヶ/m <sup>2</sup> )	硬さ (Hv)
1	128	3	53	105
2	193	6	28	120
3	247	4	44	111
4	238	7	15	128
5	308	4	41	110
6	278	5	28	105
7	286	耳切れなし	0	115
8	305	耳切れなし	0	114
9	308	耳切れなし	5	120
10	275	7	16	125
11	313	7	15	105
12	282	7	17	108
13	269	6	22	120
14	265	耳切れなし	1	131
15	348	耳切れなし	8	138
16	300	耳切れなし	8	118
17	280	耳切れなし	9	125
18	277	耳切れなし	8	140
19	312	耳切れなし	5	115
20	306	耳切れなし	6	123
21	311	耳切れなし	8	139
22	226	7	14	124
23	229	6	15	123
24	256	7	13	117

[0039]

[Table 3]

パス	1	2	3	4	5	6	7
板厚 (mm)	22.5	16.9	11.8	8.3	5.8	4.1	3.0
圧下率 (%)	25	25	30	30	30	30	27
温度 (℃)	1190 ~1210	1160 ~1180	1110 ~1130	1070 ~1090	1050 ~1070	1020 ~1040	960 ~1000

[0040]

[Table 4]

鋼No.	成分 (wt%)									d値	σ値
	C	Si	Mn	S	Ni	Cr	Cu	N	B		
25	0.013	0.33	2.25	0.0058	7.1	16.8	3.2	0.014	—	-1.6	1.3
26	0.034	0.42	1.90	0.0036	6.0	18.3	3.9	0.009	—	-5.3	1.2
27	0.015	0.50	4.03	0.0048	8.8	19.0	2.2	0.019	0.005	-1.4	4.7
28	0.014	0.31	1.70	0.0051	8.0	17.0	3.5	0.012	—	-0.2	2.1
29	0.023	0.36	2.40	0.0009	7.5	17.0	2.5	0.009	—	-1.0	1.4
30	0.018	0.51	1.54	0.0047	7.3	16.6	1.6	0.020	—	-0.9	-0.2
31	0.031	0.35	2.40	0.0042	8.9	17.0	3	0.015	—	2.1	3.2
32	0.015	0.5	4.03	0.0037	5.5	14.3	4.3	0.023	—	-0.1	0.5
33	0.050	0.35	2.23	0.0057	7.2	17.2	3.1	0.041	—	-0.1	1.5

[0041]

[Table 5]

鋼No.	塩水噴霧試験 赤錆発生時間 (Hr)	耳切れ発生 パス (段目)	スリーパー 発生数 (ヶ/m <sup>2</sup> )	硬さ (H v)
25	311	耳切れなし	8	118
26	348	耳切れなし	5	120
27	357	耳切れなし	0	103
28	280	耳切れなし	8	110
29	311	耳切れなし	0	115
30	306	耳切れなし	6	135
31	305	5	20	110
32	251	耳切れなし	8	124
33	313	7	7	148

[0042]

[Effect of the Invention] Since the elasticity austenitic stainless steel of this invention is elasticity enough and has improved \*\* hot-working nature to the grade applicable in the field for which nonferrous metal alloys, such as \*\* plain steel, and the surface treated steel sheet or brass, are used, it is stabilized and it can supply the good product of surface quality, and the corrosion resistance exceeding \*\* surface treated steel sheet is shown. And such an outstanding property was realized in the steel which reduced nickel to less than 9%. Therefore, this invention is a thing applicable to many uses including the use which thinks design nature as important which is cheap, offers the high elasticity austenitic stainless steel of versatility, and contributes to the spread.

[Translation done.]



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**TECHNICAL FIELD**

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[The technical field to which invention belongs] Processability is a good austenitic stainless steel in elasticity, and this invention relates to the elasticity austenitic stainless steel which can be used suitable also for the building-materials use as which surface crack generating at the time of hot rolling is suppressed, and design nature is required especially.

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PRIOR ART

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[Description of the Prior Art]

[0002] Conventionally, for materials for sheet metal fabrication, such as a structural inside-and-outside board, a plain steel or its surface treated steel sheet is used abundantly from a viewpoint of processability and economical efficiency at road transport department material or the vessel row. There are also many uses which point to stainless steel-ization of these materials from the demand of improvement in design nature or corrosion resistance in the field for which these plain steels or its surface treated steel sheet is used recently. However, generally stainless steel is not elasticity like a plain steel. For this reason, in the facility currently used for processing of a plain steel, un-arranging arose in processings, such as a shortage of torque, and there was a problem that application was difficult.

[0003] As an example which attained elasticity-ization of an austenitic stainless steel, the austenitic stainless steel which realized 130 or less Hv and the with a 55 kgf/mm tensile strength [ or less 2 ] elasticity property is indicated at JP,4-72038,A by making nickel content increase to 9.0% or more, while reducing an impurity element. Moreover, in JP,6-279955,A, Cr is reduced to less than 15%, a cost fall is aimed at, and the austenitic stainless steel which attained elasticity-ization is indicated by restricting severely the content lower limit of the parts nickel, Mn, and Cu.

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**EFFECT OF THE INVENTION**

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[Effect of the Invention] Since the elasticity austenitic stainless steel of this invention is elasticity enough and has improved \*\* hot-working nature to the grade applicable in the field for which nonferrous metal alloys, such as \*\* plain steel, and the surface treated steel sheet or brass, are used, it is stabilized and it can supply the good product of surface quality, and the corrosion resistance exceeding \*\* surface treated steel sheet is shown. And such an outstanding property was realized in the steel which reduced nickel to less than 9%. Therefore, this invention is a thing applicable to many uses including the use which thinks design nature as important which is cheap, offers the high elasticity austenitic stainless steel of versatility, and contributes to the spread.

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TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] However, since the steel of JP,4-72038,A has high nickel content, it is quite disadvantageous in respect of cost compared with a plain steel or its surface treated steel sheet. Although the steel of JP,6-279955,A has \*\*\*\*\*-proof exceeding the aluminum killed steel of a plain steel, since Cr content is low too, it has come moreover, ] to show about the same corrosion resistance as a surface treated steel sheet, especially the persistence time, i.e., endurance, to \*\*\*\*.

[0005] Furthermore, in the conventional elasticity austenitic stainless steel, the problem and the bird clapper had many troubles accompanying a hot-working nature fall where the surface crack which is in the inclination which adds many austenite generation elements just because it thinks the "elasticity-ization" as important, carries out a cause also of that, and an ear crack arises or is called "sliver crack" at the time of hot rolling occurred. Such surface discontinuity is disliked especially in the use which means design nature.

[0006] Then, this invention is set to the austenitic stainless steel which attained elasticity-ization to the grade applicable in the field for which nonferrous metal alloys, such as a plain steel, its surface treated steel sheet, or brass, are used. Reduce the amount of nickel, hold down cost and the corrosion resistance exceeding a surface treated steel sheet moreover is given. in addition -- and it aims at offering the austenitic stainless steel which the yield can be good also for the use which raises hot-working nature just like SUS304, prevents generating of surface discontinuity, and attaches importance to design nature, and can be applied

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## MEANS

[Means for Solving the Problem] The above-mentioned purpose is mass % and contains less than [ nickel:5-9% ], N:0.035% or less, and Cu:1.0-5.0% C:0.04% or less less than [ Si:1.0% ], less than [ Mn:5.0% ], and Cr:15-20%. S content is restricted to 0.0060% or less, and the remainder consists of Fe and an unescapable impurity, and the relation between following the (1) formula and (2) formulas is satisfied, and the elasticity austenitic stainless steel which serves as 130 or less-Hv hardness in the state after annealing can attain.

$d \text{ value} = 1.9\text{nickel} + 32\text{C} + 27\text{N} + 0.15(\text{Mn} + \text{Cu}) - 1.5\text{Cr} + 8.5 \leq 0 \dots (1)$

$a \text{ value} = \text{nickel} + 0.5\text{Cr} + 0.7(\text{Mn} + \text{Cu}) - 18 > 0 \dots (2)$

Moreover, especially this invention contained B in 0.03% or less of range in the thing which restricted S content to 0.0030% or less among the above-mentioned stainless steel, and the pan, and makes thing offer.

[0008]

[Embodiments of the Invention] Hereafter, the matter which specifies this invention is explained based on a test result. The sample was produced as follows. Steel No.1-24 to which the various alloy-element contents shown in Table 1 were changed were ingoted, and each steel was given at 1250 degrees C, it hot-rolled after forging and at the extraction temperature of 1230 degrees C, and the hot rolled sheet steel of 3.2mm of board thickness was obtained. Hot-rolling board annealing and pickling for 1150 degrees C, and soaking 1 minute were performed to this hot rolled sheet steel, it cold-rolled to 1.4mm \*\* after that, and intermediate annealing and pickling for 1050-degree-C soaking 1 minute were performed, it finished and cold-rolled to 0.7 moremm \*\*, and finishing annealing and pickling for 1050-degree-C soaking 1 minute were performed. Thus, the cold rolled sheet steel (annealed material) was obtained.

[0009] (Corrosion resistance) The 150x150mm test piece was extracted from the above-mentioned cold-rolled sheet steel, and the salt spray test of JISZ2371 was performed. The salt spray test sprayed the NaCl solution at 35 degrees C 5%, judged rust generating by viewing and evaluated it in time required by then. In addition, 8 micrometers in galvanization thickness, 0.5g of chromate films/, and the electrogalvanizing common steel plate of m2 were used as comparison material.

[0010] A test result is shown in Table 2. Moreover, as the relation between Cr content and rust generating time is known, it shows the result to drawing 1. As Table 2 and drawing 1 show, time to result in rust generating of the electrogalvanizing common steel plate used for comparison is 260hr(s). And when Cr content is 15% or more, rather than this, the durable time to rust generating becomes long, and comes to show corrosion resistance higher than an electrogalvanizing common steel plate. Therefore, this invention prescribes Cr content to 15% or more.

[0011] (Hot-working nature) About steel No.1-24 shown in Table 1, from the columnar-crystal section of casting slab, the ingot with the thickness of 30mm, a width of face [ of 140mm ], and a length of 150mm was started, the hot rolling by the REBASU type rolling mill was carried out, and hot-working nature was evaluated. Rolling conditions are shown in Table 3. The number of paths which the ear piece generated was checked visually, and it considered as the evaluation index of hot-working nature. Furthermore, the sliver crack which is the surface discontinuity generated on the steel plate front face after hot-rolling was counted, and the number of slivers per unit area was made into the evaluation index.

[0012] The result is shown in Table 2 and drawing 2. An interesting result is known from drawing 2. That is, while d value which (1) formula defined increases, the number of paths which results in generating of an ear piece falls, and generating of a sliver increases. And a clear correlation is between d value and hot-working nature, and especially sliver crack occurrences show d value and a clear straight-line relation. That is, it can be said that d value is the index by which the grade of generating of the surface discontinuity resulting from hot rolling can be evaluated with a very sufficient precision.

[0013] If it is going to apply elasticity stainless steel to the use which employed beautiful [ of the surface skin ] efficiently, there is no generating of an ear piece at the time of hot-rolling, and if generating of a sliver crack is not suppressed or less [ at most 10 //m ] to two, moreover, it will not be stood to dominance in respect of quality compared with the conventional material, such as a surface treated steel sheet and a nonferrous metal alloy. This invention persons found out that it was stabilized and a steel plate with which an ear piece is not generated and generating of a sliver becomes two or less [ 10 //m ] could be manufactured in the austenitic stainless steel by which the quality governing was carried out that this d value is zero or less so that drawing 2 might show. This point is one of the fundamental features of this invention. For steel No.8 to which d value furthermore added B or less by zero, and steel No.7 which reduced S content, the quality which whose sliver occurrences by hot rolling are zero piece/m2, and was further excellent is \*\*\*\*\*. On the other hand, although d value was zero or less, the ear piece generated steel No.10 to which S content exceeds 0.0060%, and sliver occurrences are also over ten pieces/m2.

[0014] S in a hot rolling temperature region carries out the segregation of the degradation of the hot-working nature of an austenitic stainless steel to the interface of an austenite grain boundary or an austenite phase, and a delta-ferrite phase, and it is thought that it originates in reducing the bonding strength of these grain boundaries or an interface. On the other hand, a delta ferrite is considered that the degree of dissolution of S is high compared with an austenite phase. (1) the Ming kana from a formula -- d value falls with the fall of an austenite generation element content like That is, in low component composition, the amount [ in / a hot rolling temperature region / in d value ] of delta-ferrite generation increases. And it is imagined as what the delta-ferrite phase which d value generated in the moderate amount in zero or less component composition in the hot rolling temperature region dissolves S, the deformability at the time of hot-rolling improves since the interface bonding strength of an austenite phase and a delta-ferrite phase therefore increases, consequently loses ear piece generating, and can reduce generating of a sliver to ten pieces/m2.

[0015] It is thought that S content which exists in steel originally depends [ in addition to dissolution of S by the delta ferrite ] on the result [ that hot-working nature improved very much in the aforementioned steel No.7 whose S content d value is zero or less, and is 0.0020% or less ] by which the fall of the interface bonding strength of an austenite phase and a delta-ferrite phase was suppressed further for a low reason. Conversely, by the aforementioned steel No.10 by which S content exceeds 0.0060% although d value is zero or less, S which carries out a segregation to an interface also by S dissolution by the delta ferrite cannot fully be absorbed, consequently it is thought that good hot-working nature was not obtained.

[0016] Furthermore, it is thought that B is an element which demonstrates the operation to which the segregation also of the left hand lay is preferentially carried out, and the bonding strength of an interface is increased according to the segregation in addition to the interface of an austenite phase and a delta-ferrite phase. Therefore, it is thought that steel No.8 which added B have an effect on much more hot-working disposition.

[0017] (Elasticity property) The sample was extracted from the aforementioned cold rolled sheet steel, and the Vickers determination of hardness specified to JIS2244 was carried out. The result is shown in Table 2.

[0018] The relation between a value and hardness is shown in drawing 3 about steel No.7-9, and 11-22. If the inclination for hardness to fall with the increase in a value is shown and a value exceeds 0, it turns out that it is elasticity-ized by 130 or less Hv. That is, when nickel content adjusted the component in the austenitic stainless steel with which Cr content is 15% or more including 1 - 5% of Cu at less than 9%, and d value filled zero or less so that a value might exceed 0, hot-working nature was good and hardness found out that a 130 or less-Hv elasticity austenitic stainless steel was obtained. This point is the 2nd feature of this invention. When it considers as the chemical composition to which a value exceeds 0 by such component system, in order that the austenite phase of a cold rolled sheet steel may be stable, work hardening is suppressed, and it is thought that elasticity-ization is attained.

[0019] By the way, in drawing 3, if C and N content are high even if a value exceeds 0 like steel No.18 or steel No.21, it will be expected that hardness rises by solid solution strengthening. Then, about that to which d value fills zero or less, and a value exceeds 0, C and N content investigated the influence which it has on hardness, and obtained the relation between drawing 4 and drawing 5.

[0020] The Vickers hardness number of steel No.8, and 19-21 to which N content was changed from 0.012% to 0.043%, and the relation of N content are shown by using 7nickel-16.5Cr as the base at drawing 4. Moreover, the Vickers hardness number of steel No.7, and 16-18 to which C content was changed from 0.010% to 0.049%, and the relation of C content are shown by using 7nickel-16Cr as the base at drawing 5. An increase of N content or C content increases hardness. In order to elasticity-ize to 130 or less Hv, it turns out that it is necessary to make the amount of N 0.035% or less, and to make the amount of C 0.040% or less.

[0021] Next, the reason for limitation of each component element is explained.

C: If C is contained so much, proof stress will rise 0.2% by solid solution strengthening, and hardness will increase it as mentioned above. For this reason, a content is restricted to 0.04% or less.

[0022] N: If N as well as C is contained so much, proof stress will rise 0.2% by solid solution strengthening, and hardness will increase as mentioned above. For this reason, a content is restricted to 0.035% or less.

[0023] Although Si:Si is an effective element as a deoxidizer at the time of an ingot, in order to maintain elasticity nature, it becomes difficult for the content to fill 130 or less-Hv hardness, if the method of a low is desirable and exceeds 1.0%. For this reason, it is necessary to regulate to 1.0% or less of content (for it not to contain 0%). Furthermore, it is very effective to reduce Si content when making the "springback" in bending small. When the amount of springbacks after bending was measured about the steel plate of 1mm of board thickness as an example and the R/t value when setting a bending section radius to R and setting board thickness to t was 6, in what made Si content less than 0.5% among this invention steel to the amount of springbacks having all been 3 degrees in commercial SUS304 and a commercial galvanized steel sheet, it became 2 degrees. Moreover, when a R/t value was 10, in what made Si content less than 0.5% among this invention steel to each having been 6 degrees in commercial SUS304 and a commercial galvanized steel sheet, it became 4 degrees. Since the amount of springbacks will become large if Si content becomes 0.5% or more when applying to building-materials uses, such as a roof, a shell plate, etc. fabricated to the corrugated plate of a small bending angle with a press, configuration freeze nature deteriorates, and there is a possibility of producing the problem that a desired configuration is not acquired. Therefore, it is desirable to make Si content into less than 0.5% in a building-materials use.

[0024] Although Mn:Mn is desirable to elasticity-izing since proof stress declines 0.2% with the increase in a content, there is a possibility of the refractories injury at the time of steel manufacture being caused if contained so much, and inclusion increasing, and spoiling the design nature of a product. Therefore, it specifies to 5.0% or less of content (it does not contain 0%) with which

the effect of elasticity-izing is saturated.

[0025] S: Since hot-working nature deteriorates with the increase in a content, restrict S to 0.0060% or less of content. Moreover, when aiming at much more hot-working disposition top, restricting to 0.0030% or less is desirable.

[0026] nickel:nickel is an element indispensable to an austenitic stainless steel, and it needs at least 5%. A property [ elasticity / increase / in the content ] / is shown. However, nickel is an expensive element, and since elasticity nature can be attained by less than 9.0% of content, the upper limit is made into less than 9.0% in this invention which means cheap-ization.

[0027] Cr:Cr needs to consider as 15% or more from a corrosion resistance point. However, since hardness will increase from the point of elasticity-izing if contained so much, the upper limit is made into 20% or less.

[0028] Cu:Cu needs 1.0% or more for being the useful element which elasticity-izing and a moldability contribute to improvement, and acquiring the effect. In this invention which furthermore means nickel reduction, by considering as Cu content exceeding 2.0%, the flexibility of nickel content is expanded, it becomes easy to reduce nickel to about 5% which is the lower limit, and it can contribute to cost reduction further. For this reason, although the minimum of Cu content considers as 1.0%, it is desirable to make it contain exceeding 2.0%. On the other hand, since superfluous content has a bad influence on hot-working nature, the upper limit of a content is made into 5.0%.

[0029] Mo: Although Mo is not an indispensable alloying element in this invention, as for Mo, it is effective to add Mo, since it is an element useful on an anti-corrosion disposition, especially when applying to the use of building materials, such as a roof and a shell plate, etc. However, since elevation of hardness will be caused if it exceeds 3.0%, when adding Mo, it is desirable to consider as 3.0% or less of range.

[0030] B: B is an element useful to improvement in hot-working nature. It is very effective, when especially S content exceeds 0.0030% and raising hot-working nature by B addition extends the flexibility of the content of other alloy elements. However, if B is made to contain exceeding 0.03%, hot-working nature will come to deteriorate on the contrary. Therefore, in adding B, it considers as 0.03% or less of content range.

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EXAMPLE

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[Example] Steel No.25-33 shown in Table 4 were ingoted, and each steel was given at 1250 degrees C, it hot-rolled after forging and at the extraction temperature of 1230 degrees C, and the hot rolled sheet steel of 3.2mm of board thickness was obtained. Hot-rolling board annealing and pickling for 1150 degrees C, and soaking 1 minute were performed to this hot rolled sheet steel, cold-rolling was carried out to 1.4mm \*\* after that, intermediate annealing and pickling for 1050-degree-C soaking 1 minute were performed, it cold-rolled again to 0.7mm \*\* after that, and finishing annealing and pickling for 1050-degree-C soaking 1 minute were performed.

[0032] The sample was extracted from the obtained finishing cold-rolled board, and Vickers hardness number was measured. Moreover, from the columnar-crystal section of casting slab, the ingot with the thickness of 30mm, a width of face [ of 140mm ], and a length of 150mm was started, and it hot-rolled on the conditions shown in Table 3 with the REBASU type rolling mill. The number of paths which the surface discontinuity of an ear piece, a sliver, etc. generated was checked visually, and it considered as the evaluation index of hot-working nature. Moreover, the corrosion resistance test was also performed. The test piece size was set to 150mmx150mm, and the salt spray test of JISZ2371 performed corrosion-resistant evaluation. The salt spray test sprayed the NaCl solution at 35 degrees C 5%, and evaluated it in time required by \*\*\*\*.

[0033] These results are collectively shown in Table 5. d value is zero or less and hardness is 130 or less Hv the top where this invention steel No.25-29 to which a value exceeds 0 have good hot-working nature. The \*\*\*\* time of this invention steel containing 15 more% or more of Cr is over 260hr(s) which are the \*\*\*\* time of an electrolytic-zinc plating common steel plate, and shows sufficient corrosion resistance.

[0034] If comparison steel No.30 are compared with this invention steel No.25, although all, on the other hand, contain about 7% of nickel, and about 16.5% of Cr To hardness being Hv118 and elasticity, since the content of Mn with this invention steel No.25 [ effective in elasticity-izing ] and Cu is high and a value is over 0, since a value has become [ Mn and Cu content ] low less than zero, as for comparison steel No.30, hardness indicates a high value to be Hv135. Moreover, by comparison steel No.33, if this invention steel No.25 are compared with comparison steel No.33, although Mn and Cu also contain to the same extent in addition to nickel and Cr, since C contains and N all contains both highly with 0.041% 0.050%, hardness indicates a high value to be Hv148.

[0035] Although hardness is 130 or less Hv since, as for comparison steel No.31, a value is over 0, since d value is over 0, hot-working nature is still poorer.

[0036] Moreover, since a value exceeds 0 and d value has become zero or less, although hardness is Hv110 and elasticity and comparison steel No.32 have good hot-working nature, since Cr content is as low as 14.3%, from rust time serves as 251hr(s). Therefore, corrosion resistance is inferior to an electrogalvanizing common steel plate.

[0037]

[Table 1]



鋼No.	成分 (wt%)									d値	s値
	C	Si	Mn	S	NI	Cr	Cu	N	B		
1	0.019	0.28	1.70	0.0058	8.5	10.8	4.4	0.020	—	10.5	0.2
2	0.021	0.30	1.52	0.0040	6.8	12.5	2.5	0.019	—	4.5	-2.1
3	0.015	0.32	0.78	0.0046	11.2	14.4	0.1	0.006	—	9.0	1.0
4	0.029	0.29	1.17	0.0050	7.0	14.3	2.5	0.020	—	2.4	-1.3
5	0.010	0.13	0.10	0.0048	12.1	16.9	4.5	0.010	—	7.4	5.8
6	0.020	0.1	1.49	0.0040	9.5	15.5	4.5	0.009	—	5.1	3.4
7	0.010	0.31	2.50	0.0012	7.1	16.0	3.4	0.010	—	-0.5	1.2
8	0.012	0.33	2.00	0.0043	7.3	16.5	3.1	0.010	0.005	-1.0	1.1
9	0.018	0.32	2.50	0.0032	6.8	16.8	3.5	0.013	—	-2.0	1.4
10	0.014	0.33	2.50	0.0070	6.2	15.9	3.8	0.011	—	-1.9	0.6
11	0.011	0.29	2.30	0.0044	8.8	16.7	3.1	0.016	—	1.8	2.9
12	0.015	0.32	2.40	0.0048	8.2	15.8	3.9	0.017	—	2.3	2.5
13	0.021	0.28	2.02	0.0032	8.4	15.2	2.9	0.009	—	3.3	1.4
14	0.010	0.33	2.80	0.0051	5.5	15.2	4.1	0.012	—	-2.2	-0.1
15	0.062	0.51	0.20	0.0049	8.1	18.2	0.2	0.030	—	-0.8	-0.5
16	0.022	0.31	2.43	0.0058	6.9	16.2	3.3	0.009	—	-0.9	1.0
17	0.035	0.31	2.60	0.0040	6.8	15.9	3.6	0.012	—	-0.1	1.1
18	0.049	0.31	2.48	0.0049	6.9	16.3	3.4	0.010	—	-0.1	1.2
19	0.010	0.33	2.10	0.0051	7.3	16.5	3.1	0.020	—	-0.7	1.2
20	0.009	0.3	1.98	0.0044	7.2	16.4	3	0.028	—	-0.6	0.9
21	0.013	0.29	2.05	0.0038	7.4	16.6	2.9	0.043	—	0.0	1.2
22	0.010	0.29	4.80	0.0052	5.1	13.0	4.5	0.008	—	0.6	0.1
23	0.008	0.31	4.10	0.0046	5.8	13.5	4.3	0.012	—	1.1	0.4
24	0.012	0.33	4.30	0.0040	6.2	14.6	3.1	0.010	—	0.1	0.7

[0038]

[Table 2]

鋼No.	塩水噴霧試験 赤錆発生時間 (Hr)	耳切れ発生 バス (段目)	スリーパー 発生数 (ヶ/m <sup>2</sup> )	硬さ (Hv)
1	128	3	53	105
2	193	6	28	120
3	247	4	44	111
4	238	7	15	128
5	308	4	41	110
6	278	5	28	105
7	286	耳切れなし	0	115
8	305	耳切れなし	0	114
9	308	耳切れなし	5	120
10	275	7	16	125
11	313	7	15	105
12	282	7	17	108
13	269	6	22	120
14	265	耳切れなし	1	131
15	348	耳切れなし	8	138
16	300	耳切れなし	6	118
17	280	耳切れなし	9	125
18	277	耳切れなし	8	140
19	312	耳切れなし	5	115
20	306	耳切れなし	6	123
21	311	耳切れなし	8	139
22	226	7	14	124
23	229	6	15	123
24	256	7	13	117

[0039]

[Table 3]

パス	1	2	3	4	5	6	7
板厚 (mm)	22.5	16.9	11.8	8.3	5.8	4.1	3.0
圧下率 (%)	25	25	30	30	30	30	27
温度 (℃)	1190 ~1210	1160 ~1180	1110 ~1130	1070 ~1090	1050 ~1070	1020 ~1040	960 ~1000

[0040]

[Table 4]

鋼No.	成分 (wt%)									d値	a値
	C	Si	Mn	S	Ni	Cr	Cu	N	B		
25	0.013	0.33	2.25	0.0058	7.1	16.8	3.2	0.014	—	-1.6	1.3
26	0.034	0.42	1.90	0.0036	6.0	18.3	3.9	0.009	—	-5.3	1.2
27	0.015	0.50	4.03	0.0048	8.8	19.0	2.2	0.019	0.005	-1.4	4.7
28	0.014	0.31	1.70	0.0051	8.0	17.0	3.5	0.012	—	-0.2	2.1
29	0.023	0.36	2.40	0.0009	7.5	17.0	2.5	0.009	—	-1.0	1.4
30	0.018	0.51	1.54	0.0047	7.3	16.6	1.6	0.020	—	-0.9	-0.2
31	0.031	0.35	2.40	0.0042	8.9	17.0	3	0.015	—	2.1	3.2
32	0.015	0.5	4.03	0.0037	5.5	14.3	4.3	0.023	—	-0.1	0.5
33	0.050	0.35	2.23	0.0057	7.2	17.2	3.1	0.041	—	-0.1	1.5

[0041]

[Table 5]

鋼No.	塩水噴霧試験 赤錆発生時間 (Hr)	耳切れ発生 パス (段目)	スリーパー 発生数 (ヶ/m <sup>2</sup> )	硬さ (Hv)
25	311	耳切れなし	8	118
26	348	耳切れなし	5	120
27	357	耳切れなし	0	103
28	280	耳切れなし	8	110
29	311	耳切れなし	0	115
30	306	耳切れなし	6	135
31	305	5	20	110
32	251	耳切れなし	8	124
33	313	7	7	148

[Translation done.]

\* NOTICES \*

**Japan Patent Office is not responsible for any damages caused by the use of this translation.**

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] The graph showing the relation between Cr content in a salt spray test, and rust generating time.

[Drawing 2] The graph showing the relation between d value in a hot rolling examination, sliver crack occurrences, and the number of ear piece generating paths.

[Drawing 3] The graph showing the relation between a value and Vickers hardness number.

[Drawing 4] The graph showing the relation between N content and Vickers hardness number.

[Drawing 5] The graph showing the relation between C content and Vickers hardness number.

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[Translation done.]